Replacement Page 1, Lines 1 to 20

~~Description~~

Methods for Automatically Identifying Microorganisms Collected on a Carrier

BACKGROUND OF THE INVENTION

The invention concerns methods for automatically identifying microorganisms collected on a carrier that are particles, airborne or present in water, in the form of fungal spores and bacteria.

As is known in the art, the identification of airborne particles or particles present in water is done by collecting these particles on a carrier. This carrier is advantageously positioned in a channel or at the end of a channel for supply air or water. In this connection, the carrier is a filter or a body with a coating of an adhesive. After collection, the particles are incubated on culture media in microbiological laboratories. After several days, an analysis of the colonies obtained in this way can be done. The colonies that all can be traced back to only a single collected germ are coarsely preexamined manually in regard to color, shape, and structure. A more precise determination of the species of germ is possible only after their individualization as well as growth tests and metabolic tests. This usually takes several weeks. Also, the identification of these colonies is done manually.

The invention ~~set forth in claim 1~~ has the object to automatically identify microorganisms collected on a carrier that are particles, airborne or present in water, in the form of fungal spores and bacteria.

SUMMARY OF THE INVENTION

This object is solved by the following method steps: ~~by the features listed in claim 1.~~

a) - at least one recording of the image of the carrier surface with the collected particles

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as a color image and digitalization this color image;

b) - a conversion of the digitalized color image into a grayscale image or into a grayscale image and, subsequently, into a silhouette image by at least one transformation step, wherein, when particles are present, an image is produced with resulting full-surface labeled objects of a grayscale and a background of a different grayscale;

c) - an identification of objects in the grayscale image and/or in the silhouette image by a model-based comparative method;

d) - a marking of the contours of identified objects in the color image and/or in the grayscale image;

e) - at least one feature determination of the identified objects in the color image and/or in the grayscale image;

f) - a case-by-case classification of the objects based on the at least one feature determination;

g) - an indication and/or saving of the classified objects as species and/or name and/or code of the classified and thus identified objects; and

h) - an indication and/or saving of the non-classified objects as a color image and/or grayscale image and/or silhouette image of the thus present, at least one unidentified object, wherein this object subsequently is either discarded or added as a new case with determined class in the classification system.

Replacement Page 3, Line 18, to Page 5, Line 23

~~Advantageous embodiments of the invention are presented in claims 2 to 9.~~

Advantageously, in accordance with ~~the~~ a further embodiment ~~of claim 2~~, in addition to the species the number of identified objects of said species is indicated and/or saved also. In this way, it is possible to also introduce threshold values wherein, for example, an alarm signal is triggered not only when presence is detected but also upon surpassing a certain number of certain particles.

In accordance with ~~the~~ another embodiment ~~of claim 3~~, advantageously the number of objects that are not identify are counted also so that in the case of a manual identification of these particles immediately their count is also indicated and/or saved. Another repetition based on the expanded classification system is prevented. It is possible to react more quickly to dangerous situations.

In accordance with ~~the~~ another embodiment ~~of claim 4~~, errors are advantageously purged from the image of the carrier surface with the airborne particles after digitalization and the image is standardized. During standardization, colors and differences of the images are advantageously compensated.

In accordance with ~~the~~ another embodiment ~~of claim 5~~, further features for the identification of the objects are the shape, the texture, or the structuring of the objects in the color image and/or in the grayscale image. In addition to the outer shape, visually discernable features in the interior of the objects are also incorporated into the identification.

~~The~~ Another embodiment ~~of claim 6~~ advantageously enables that objects that overlap in the images can be detected with the method according to the invention. Such objects are at least partially overlapping one another. In the case of a large number of particles on the carrier, such arrangements of particles are very likely. For this purpose, the objects that are

only partially visually discernable are individualized and compared to objects of the classification system. The objects that are only partially visually discernable are indicated and/or saved. Moreover, the correlated similar objects of the classification system are indicated and/or saved in this connection. At the same time, advantageously the level of congruence is also indicated and/or saved so that by means of a manual comparison the identification can be confirmed or discarded. The number of identified objects rises so that the result of the automatic identification is significantly increased.

In accordance with ~~the~~ another embodiment ~~of claim 7~~, the image of the carrier surface with the collected particles is recorded as a color image at least once two-dimensionally, sterically and/or three-dimensionally. By means of multiple two-dimensional images of the carrier surface with different depth of field, it is possible advantageously to determine also three-dimensional features of the objects by means of two-dimensional images. The depth of field depends on the adjusted lens width, the focal length, and the aperture. The basis is that when adjusting the lens of the camera to a certain image width, only object points within a certain object width are reproduced in the image plane. The images of object points with smaller object width are produced behind the image plane, and those of the points of greater object width are generated in front of the image plane. A sterical image is created by utilization of holography. In this connection, the hologram can advantageously be recorded by means of different image scales with a camera, for example, in the form of a digital camera. A further advantage resides in that the hologram can be represented with a plane wave at greater or smaller wavelength so that the images are also greater or smaller.

In accordance with ~~the~~ another embodiment ~~of claim 8~~, advantageously additional objects can be determined by dyeing the carrier surface. Such objects are not recognizable, or only with errors, under normal conditions without dyeing.

In ~~an~~ another embodiment ~~according to claim 9~~, the identification of objects is further improved. A first determination is realized by images of the undyed surface of the carrier. By means of subsequent dyeing, further optical properties of the object can be made

visible. A subsequent automatic determination increases the degree of identified objects significantly.

DESCRIPTION OF PREFERRED EMBODIMENTS

~~One embodiment of the invention will be described in the following in more detail.~~